# Identifying Sources of Storm Water Metal Contaminants at Navy Facilities

## How Can You Clean It Up If You Don't Know Where It's Coming From?

**NDIA E2S2**
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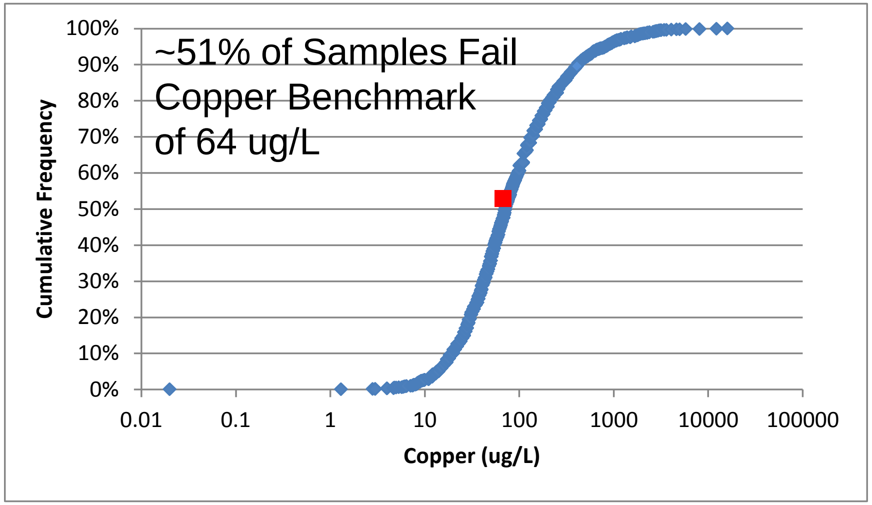
# Storm Water Problem

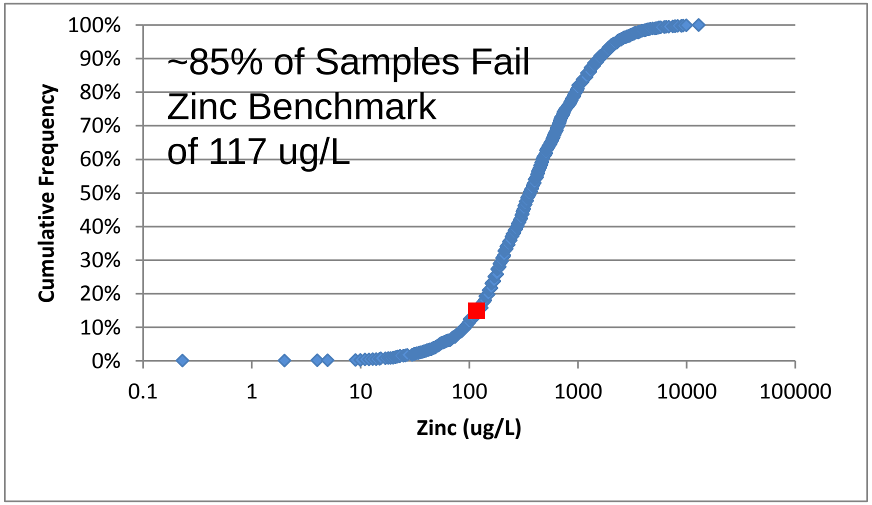
**PROBLEM:**

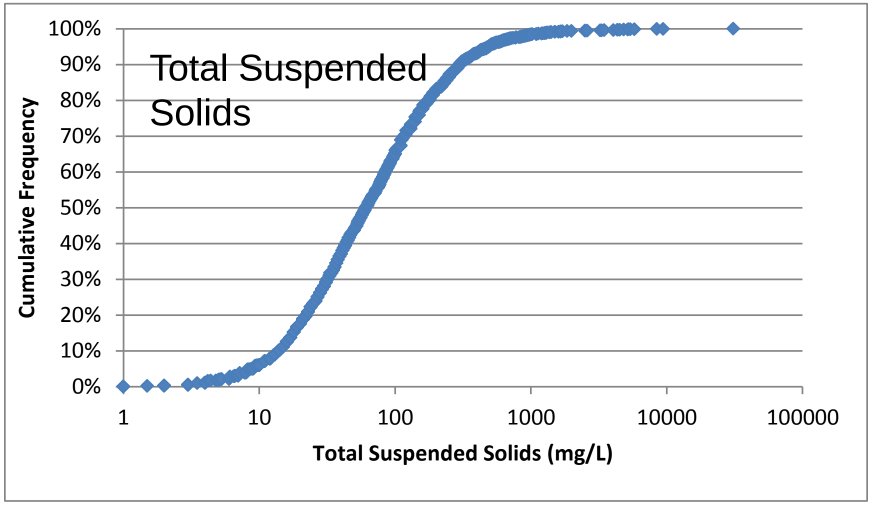
- Copper and zinc concentrations in storm water samples discharging from Navy facilities typically exceed regulatory benchmarks, limits, or proposed limits
- Storm water toxicity, primarily caused by copper and zinc, commonly exceeds San Diego thresholds
- The relative magnitude of copper and zinc sources to storm water discharges is not well known
- Where and what BMPs should be applied to best mitigate sources

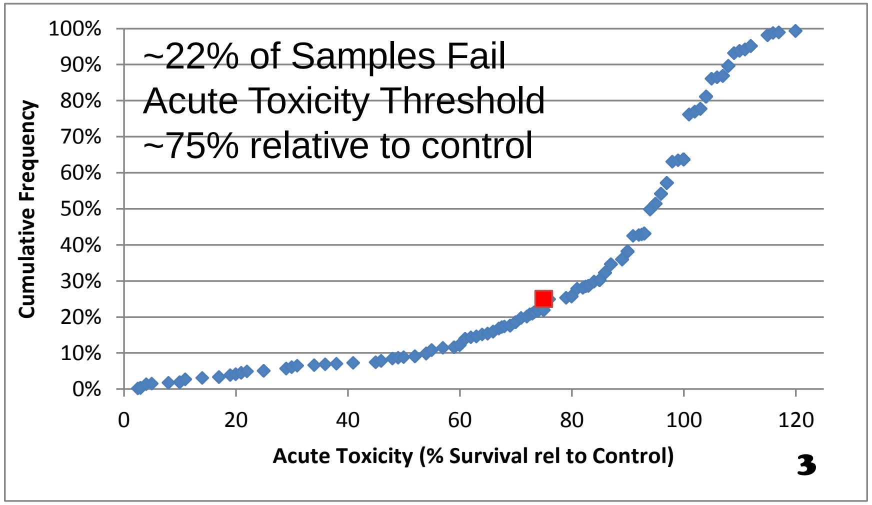
# First Flush Monitoring - SW

Data Compilation from 1994 to 2010;  n>3000



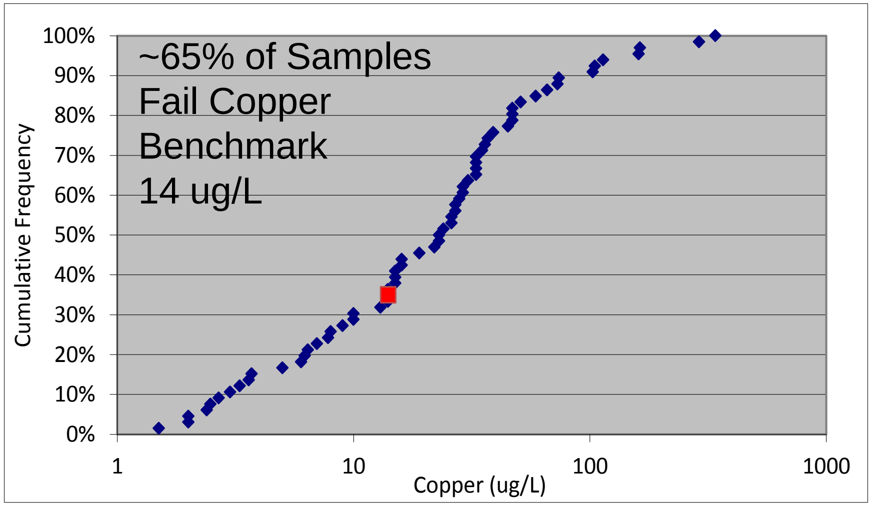



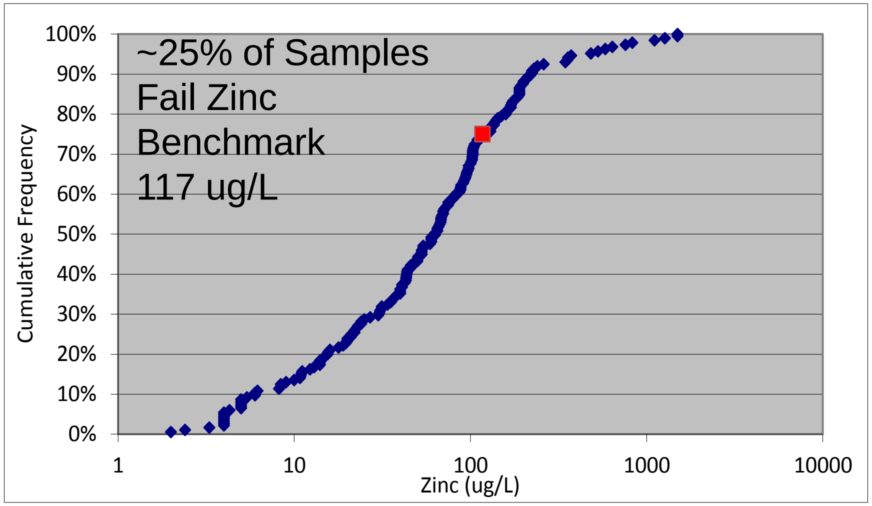



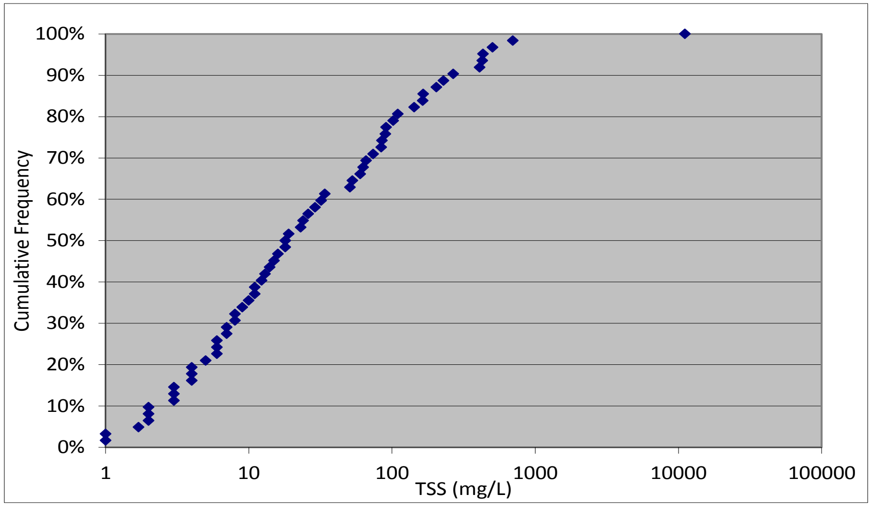



# First Flush Monitoring - NW

Data Compilation from 1998 to 2008; n~62 to185




No toxicity compliance requirement.

# Technical Objectives

Provide Navy facility environmental managers with a storm water management tool that will allow them to:

1. Identify potential sources of metals in Navy facility storm water runoff
2. Quantify relative runoff potential from area sources
3. Quantify the potential reductions expected from BMP mitigation actions

Technology Demonstration Funded by: Naval Environmental Sustainability Development to Integration (NESDI) R&D Program

# Technical Approach

1. Calibrate and validate WinSLAMM modeling tool by PV & Associates with Navy specific data:
   - Calibrated and validated for a number of urban areas across the United States and Canada
   - Focused on small storm hydrology
   - Evaluates runoff volume, particulate and dissolved pollutants
   - Utilizes national and regional pollutant loading databases
   - Includes built-in modules to evaluate storm water control practices
2. Material leachate testing
3. "Upstream" storm water sampling

# WinSLAMM Components

## Contaminant Source Loading Data

- Residential
- Institutional
- Commercial
- Industrial
- Freeway
- Other *

## Site Characterization Data

- Driveways
- Paved Parking
- Roofs
- Sidewalks
- Streets
- Other Impervious*
- Undeveloped
- Landscaped
- Unpaved Parking
- Other Pervious

## Detailed Rainfall Data

- Hourly Data
- Duration
- Intensity

## Runoff Coefficient Data

- Particle Loading
- Particle Washoff
- Particle Size

## BMP Controls

- Catchbasin Cleaning
- Biofiltration
- Infiltration
- Street Cleaning
- Detention Ponds
- Grass Swales
- Hydrodynamic Devices

**Focus is on the Other* (Navy Specific Characteristics)**

# Calibration Approach

- Collate National Pollutant Discharge Elimination System (NPDES) storm water measurement data from:
  - Multiple outfalls (9)
  - Range in drainage area size (2 - 73 acres)
  - Multiple bases (7)
  - Multiple storm events (10 - 34 /outfall)
  - Two Regions – Navy Region SW, NW
- Collect site characterization data
- Collect local rainfall data
- Compare model to measurements (n~140) and adjust model Contaminant Source File to get best fit

# WinSLAMM Navy Specific Calibration

**WinSLAMM**
Historical Contaminant Source File (CSF)

**Navy Site Specific Data**
- Storm water discharge data (multiple bases, outfalls, years)
- Drainage area site characterization
- Local Rainfall

## Iterative Calibration

**Multiple Outfalls - Multiple Events**
1. Run model with adjusted CSF
2. Compare prediction to observed
3. Readjust CSF to create Navy Best Fit

**One Outfall - Multiple Events**
1. Run model
2. Compare prediction to observed
3. Adjust CSF for Best Fit

**CSF Adjustments**
- Leachate data
- Upstream" storm water data

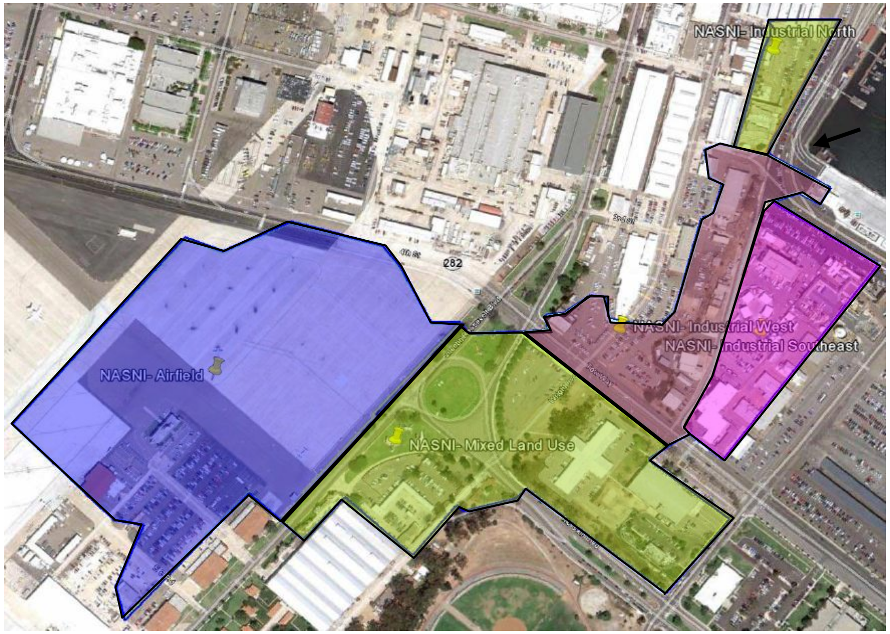
**Validation**
Apply to additional bases and outfalls

Navy Calibrated WinSLAMM CSF

# Site Characterizations

Measure an Area


*Area Output = 0.527 acres*




Method Included:

- Site visits
- Aerial photos
- GIS
- Online measurement tools

Lessons Learned:

- Site visit critical
- Break drainage areas into smaller "like" components
- Modified WinSLAMM to handle multiple sub-drainages

# Site Characterizations

Site Characterization: Buildings, Materials, Pavement Slope and Quality

NESDI — Navy Environmental Sustainability Development to Integration

# Site Characterizations

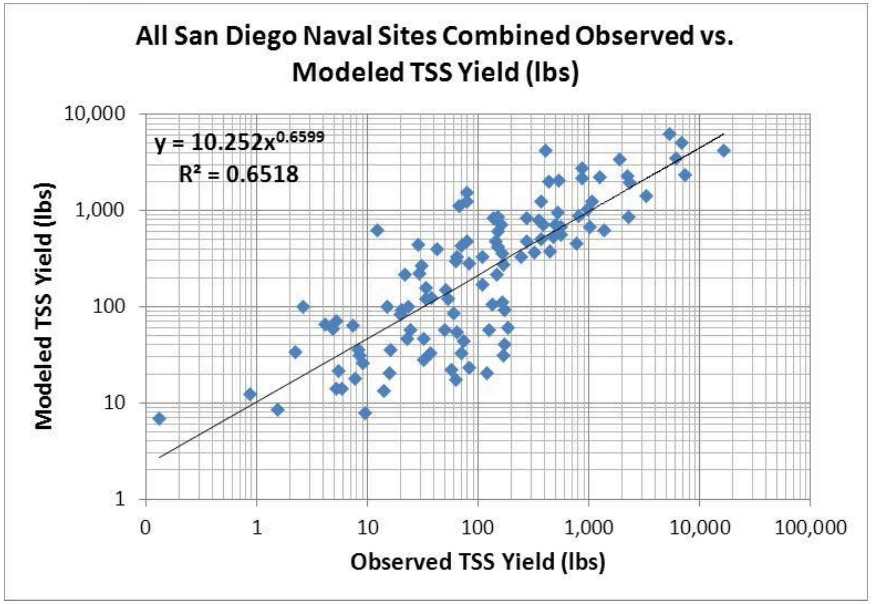
SPAWAR Systems Center PACIFIC

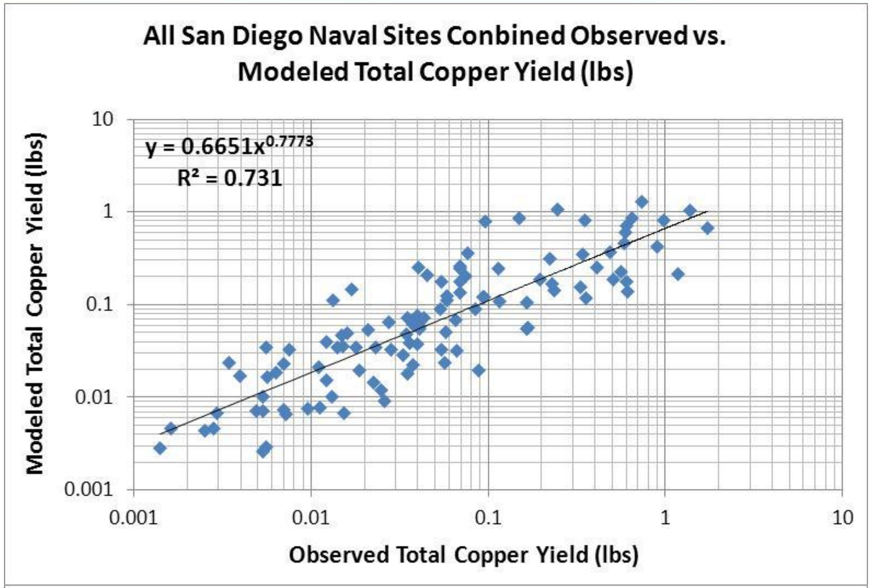
# Model Calibration Issues

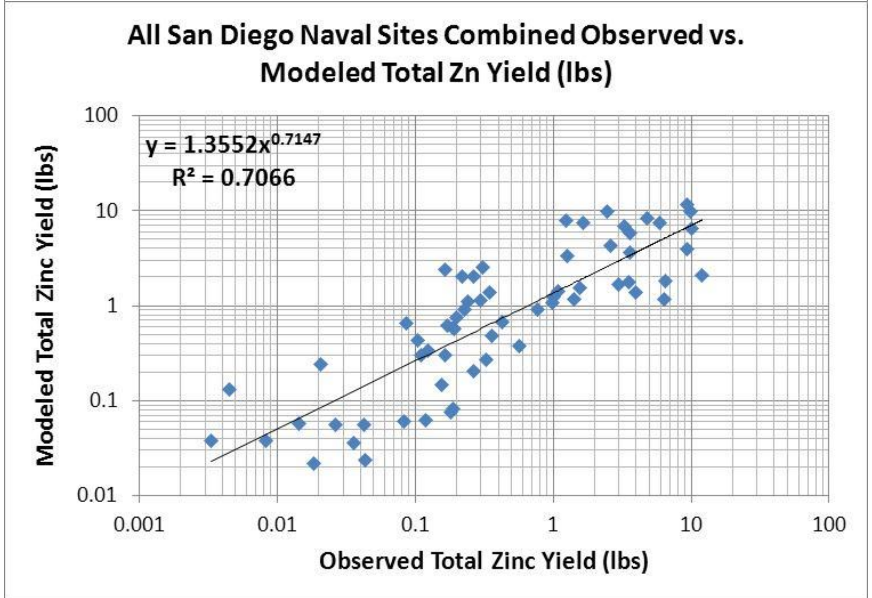
## Data Issues:

- First Flush vs. Event Meant Concentration Data
- Limited Flow Data
- Limited Total vs. Dissolved Data
- Limited Particle and No Particle Size Data
- Lack of Relationship of Outfall Concentrations with Rainfall Intensity, Volume, Antecedent Dry Period
- Rainfall Locations (NW)
- Regional Differences

# Model Results – Region SW



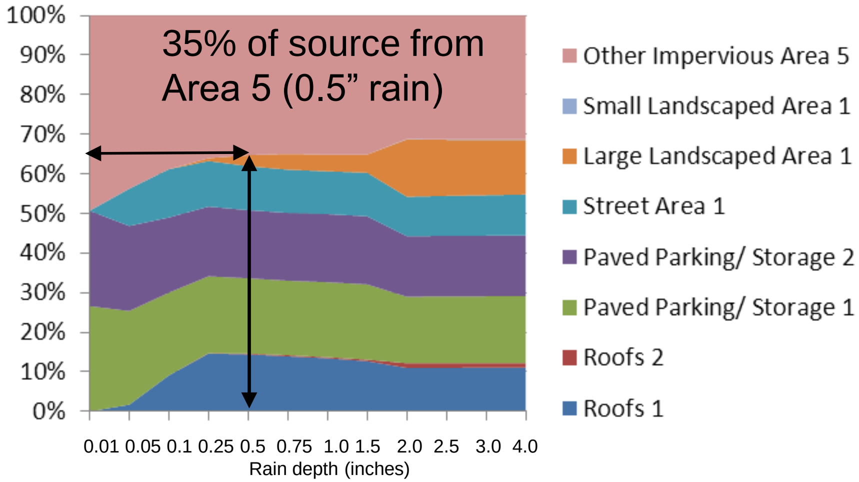




- Reasonable model predictions for Region SW
- Coefficients of variation (COV) within ~50%
- Region NW predictions not as good ($r^2$~0.5) but typically with COV ~60%

# Model Results Example

Relative Contributions by Rainfall Total





**Model Outcome Example:**

- Other Area 5 (20% of Area): 35% runoff, 72% TSS, 81% Cu, 63% Zn
- Paved storage (11% of Area): 19% runoff, 13% Zn

**Focus BMP on "Other Impervious Area 5" area**

# Relative Source Magnitude

| | Area Characteristic Description | Acres | Acre % | Modeled Cu (lbs/ac/yr) | Cu (lbs/yr) | Percentage Cu source | Source/Acreage |
|---|---|---|---|---|---|---|---|
| AREA1 | flat roofs to silty soil | 0.55 | 4% | 0.00045 | 0.000 | 0.0% | 0% |
| AREA2 | flat roofs directly connected | 0.76 | 6% | 0.00879 | 0.007 | 0.3% | 5% |
| AREA3 | paved parking directly connected | 3.5 | 28% | 0.23833 | 0.834 | 40.2% | **142%** |
| AREA4 | streets rough asphalt (40 ft wide) | 0.77 | 6% | 0.03087 | 0.024 | 1.1% | 18% |
| AREA5 | baseball field (silty soil) | 1.2 | 10% | 0.00156 | 0.002 | 0.1% | 1% |
| AREA6 | silty soil near buildings | 1.8 | 15% | 0.00357 | 0.006 | 0.3% | 2% |
| AREA7 | mod use concrete pier/laydown/storage/loading dock | 1.8 | 15% | 0.33076 | 0.595 | 28.7% | **197%** |
| AREA8 | heavy use concrete pier/laydown/storage/loading dock | 0.9 | 7% | 0.49562 | 0.446 | 21.5% | **296%** |
| AREA9 | mod use asphalt pier/laydown/storage/loading dock | 0.9 | 7% | 0.15200 | 0.137 | 6.6% | 91% |
| AREA10 | other imperv areas with galvanized materials | 0.2 | 2% | 0.11367 | 0.023 | 1.1% | 68% |
| TOTAL | | 12.38 | 100% | | 2.074 | 100% | 1 |

Use of Relative Source Magnitude for Effective BMP Mitigation

# Source Strength Measurements

Standardized method to quantify relative source strength of copper and zinc leaching from common materials

# Leachate Rate Results - Cu

| Photo | Surfaces | Location | Cu Surface Release Rate (µg/$ft^2$) |
|---|---|---|---|
|  | Galvanized shack, sides | NBK Bangor | 164.4 |
|  | Wood, treated, green | NBK Bangor | 152.7 |
|  | Galvanized scaffold stack, laydown area | SUBASE | 93.0 |
|  | Concrete wall | SSC-PAC | 77.1 |
|  | Treated wood, green painted. | SUBASE | 33.6 |
|  | Hose, black, 4" diameter | SUBASE | 30.5 |
|  | Galvanized Fence, coated black | SSC-PAC | 24.4 |
|  | Dumpster, green | SSC-PAC | 16.4 |
| | Conex box, blue | SUBASE | 11.9 |
|  | Cable, black, 4" diameter | SUBASE | 7.4 |

Above benchmark

Background
<4 µg/$ft^2$

# Leachate Rate Results - Zn

| Photo | Surfaces | Location | Zn Surface Release Rate (µg/ft$^2$) |
|---|---|---|---|
|  | Galvanized scaffold stack, laydown area | SUBASE | 20,123 |
|  | Galvanized fence | SUBASE | 5,375 |
|  | Galvanized rail | SUBASE | 5,170 |
|  | Galvanized siding, painted, chipped | NBK Bangor | 1,824 |
|  | Galvanized shack, sides | NBK Bangor | 1,411 |
|  | Wood, treated, green | NBK Bangor | 455 |
|  | Building side, yellow, panels | NAS Whidbey | 416 |
|  | Hose, black, 4" diameter | SUBASE | 357 |
|  | Shed Roof, green coated metal - First Wash | NAVSTA Everett | 353 |
| | Shed Roof, green coated metal - Second Wash | NAVSTA Everett | 253 |

Background <50 µg/ft$^2$

Above benchmark

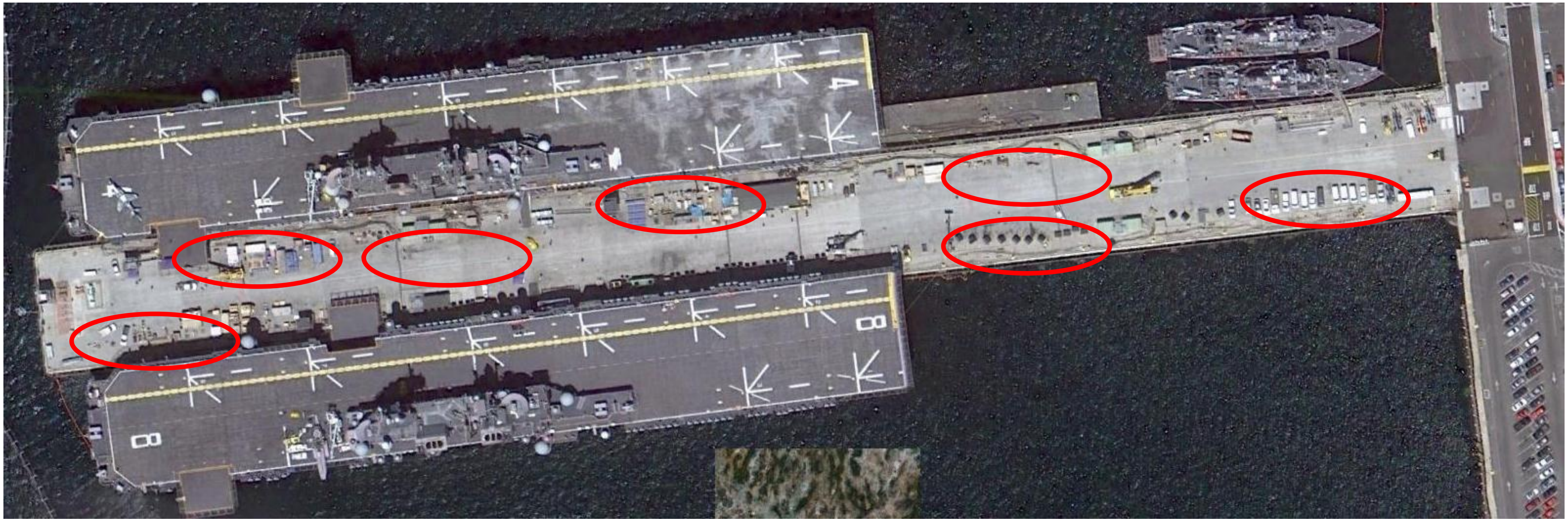
# Upstream Sampling

## Pier Sampling

- Large differences over short distances associated with materials and operations
- WinSLAMM modified to allow for refined sub-drainage sources

| SAMPLE ID | Cu (ug/l) |
|---|---|
| P13-3 | 1132 |
| P13-14 | 271 |
| P13-9 | 266 |
| P13-15 | 111 |
| P13-13 | 99 |
| P13-5 | 95 |
| P13-12 | 74 |
| P13-4 | 60 |
| P13-1 | 55 |
| P13-8 | 50 |
| P13-10 | 37 |
| P13-16 | 2.9 |

| SAMPLE ID | Zn (ug/l) |
|---|---|
| P13-16 | 8916 |
| P13-3 | 5908 |
| P13-14 | 1489 |
| P13-9 | 714 |
| P13-15 | 446 |
| P13-4 | 422 |
| P13-13 | 384 |
| P13-8 | 324 |
| P13-5 | 314 |
| P13-1 | 312 |
| P13-12 | 261 |
| P13-10 | 104 |



# Summary

- WinSLAMM model calibration shows reasonable success in identifying/quantifying relative source areas at Navy facilities
- Limited nature of NPDES storm water monitoring data is main source of uncertainty
- Regional adjustments may be required
- Leachate and “upstream” source sampling should provide model refinements
- Implementation pathway likely a more simplified spreadsheet version (output) of the model focused on relative size of validated source strengths

# Acknowledgments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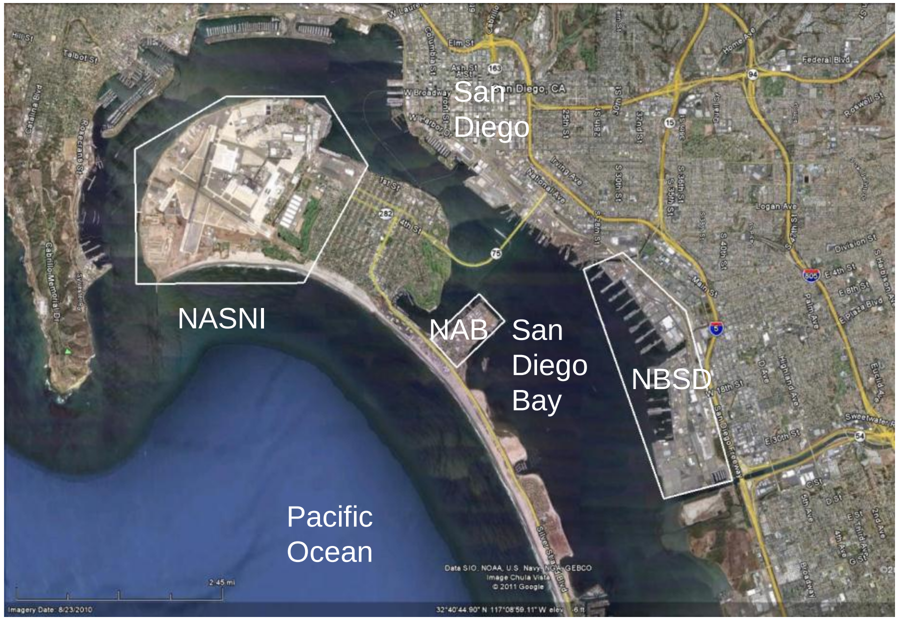
- Ryan MacLure, Vicky Ngo, Chantry Davis – NAVFAC SW
- Base Managers from Navy SW and NW Region
- NESDI R&D Program

# Questions?

# Site Characterizations





Bangor – detention pond

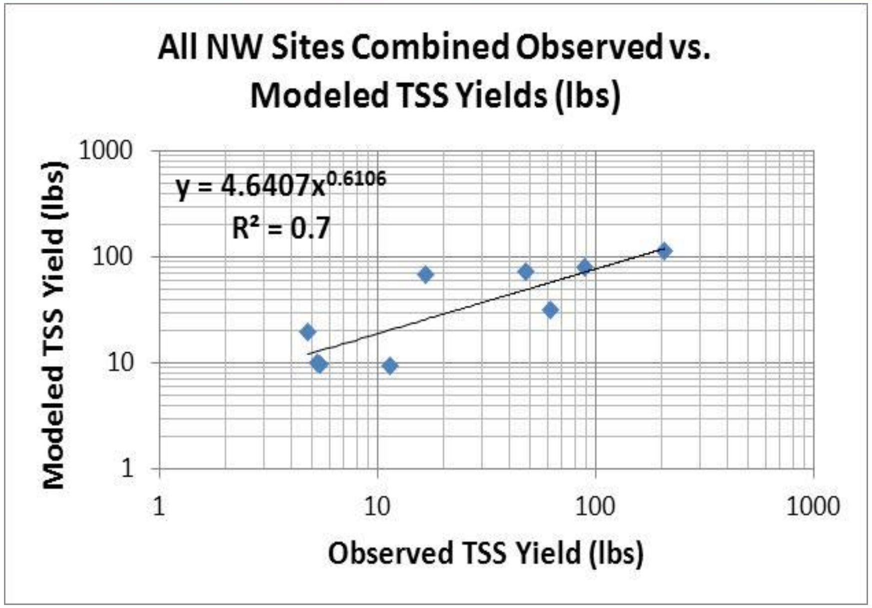
# Model Results – Region SW

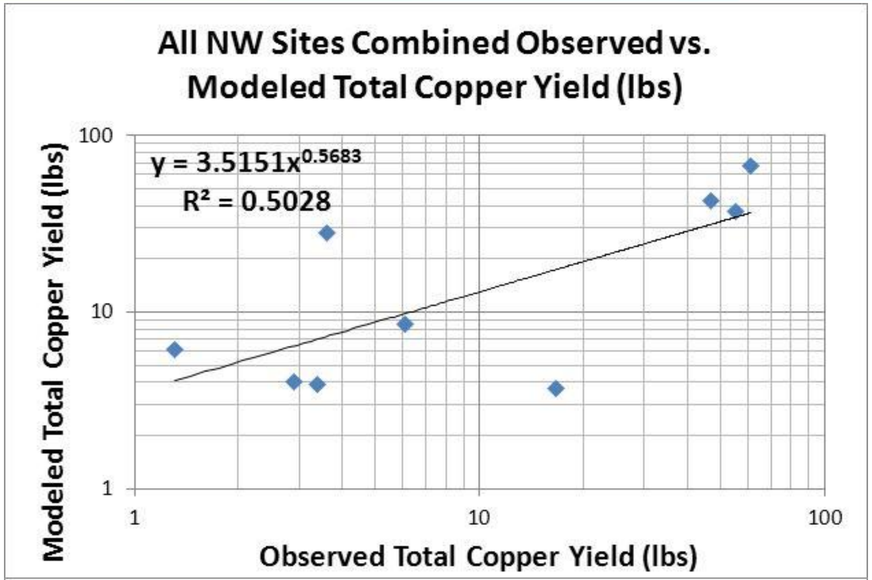
**Observed and Modeled Cu Concentrations and Yields at San Diego Naval Facility Study Areas**

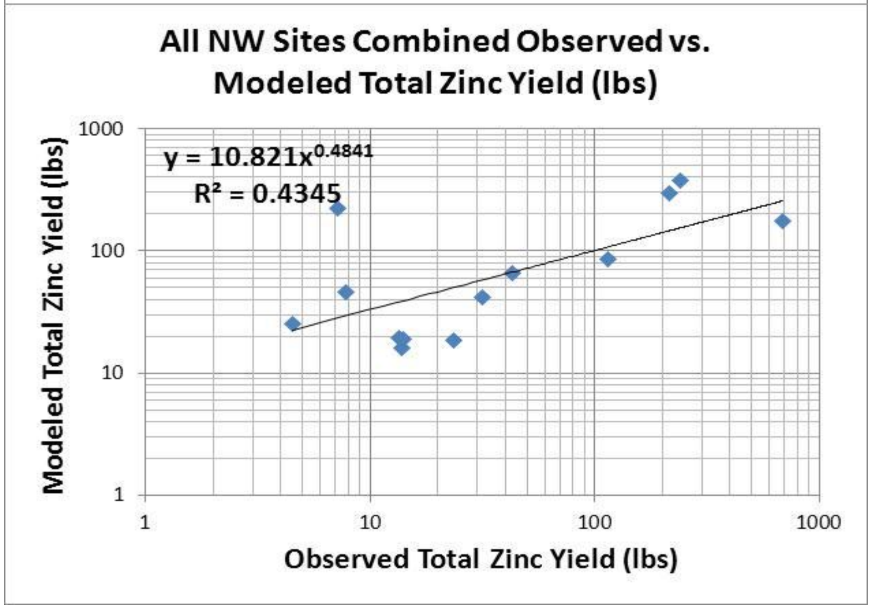
| | Total Cu observed average conc. (µg/L) | Total Cu modeled average conc. (µg/L) | Total Cu observed total yield (lbs) | Total Cu modeled total yield (lbs) | Yield Observed/ Modeled |
|---|---|---|---|---|---|
| Naval Air Base Outfall #26 | 66 | 53 | 8.16 | 6.22 | 131% |
| Naval Base San Diego Outfall #14 (mixed industrial activities) | 69 | 69 | 7.47 | 9.36 | 80% |
| Naval Base San Diego Outfall #1 (ceremonial pier) | 137 | 117 | 0.26 | 0.26 | 100% |
| Naval Base San Diego Outfall #13 (heavy industrial pier) | 342 | 288 | 1.8 | 1.6 | 113% |
| Naval Amphibious Base (NAB) Outfall #9 (industrial area and ball field) | 163 | 177 | 0.69 | 0.99 | 70% |

Observed/Modeled data (Region SW) typically within 50%

# Model Results – Region NW




- Less available data
- Not as good model prediction
- Lots of variability
- Regional difference (~ factor of 2)

# Model Results – NW

**Observed and Modeled Zn Concentrations and Yields at Northwest Naval Facility Study Areas**

| | Total Zn observed average (µg/L) | Total Zn modeled average (µg/L) | Total Zn observed total yield (lbs) | Total Zn modeled total yield (lbs) | Yield Observed/ Modeled |
|---|---|---|---|---|---|
| Indian Island | 150 | 192 | 133 | 127 | 105% |
| Whidbey Island | 183 | 156 | 1,026 | 636 | 161% |
| Everett | 80 | 308 | 257 | 646 | 40% |
| Sum for all observed events | | | 1,416 | 1,409 | 100% |

Observed/Modeled data typically within 60%